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SHIPBOARD HABITABILITY DURING LOW FREQUENCY ACTIVE SONAR OPERATIONS: MOOD EFFECTS

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Summary

Problem

Shipboard personnel must be adequately protected from exposure to low frequency active sonar (LFAS) to perform their jobs effectively. The amount of noise which can be tolerated without performance impairment must be established to make efficient ship design decisions.

Objective

The present study examined the effects of LFAS exposure on mood as one index of the psychological effects of LFAS on crew readiness and performance.

Approach

Mood and personality questionnaires were completed by two groups of participants the day before LFAS exposure, the day of LFAS exposure, and the day after LFAS exposure. LFAS exposure was at 83 dB for one group and 89 dB for the other. Exposure lasted 24 hours for each group. Mood was measured in the morning, at midday, and in the evening of each study day.

Results

LFAS exposure was associated with an increase in negative mood states relative to the pre-exposure mood. The LFAS exposure effect was particularly pronounced in individuals whose personality predisposed them to strong emotional reactions to stress. However, the key finding was that these LFAS exposure effects were the same at 89 dB as at 83 dB.

Conclusion

Alternative ship designs which produce LFAS exposure values in the 83 dB to 89 dB range are equivalent with respect to their impact on mood and activation.

Introduction

Sonar is an important technology for combat ships, but active use of sonar exposes the ship's crew to noise. This exposure is a factor in ship design because excessive noise can impair performance directly (e.g., by hampering voice communications) or indirectly (e.g., by adverse effects on sleep). Sonar exposure can be controlled by soundproofing and other design considerations, but soundproofing may preclude the introduction of other desirable ship design elements which must be traded off with soundproofing to stay within cost, space, and weight limitations constraining the design. Optimal ship design therefore must balance the costs and benefits of soundproofing. It is necessary to determine the effects of sonar exposure with some precision to perform the required cost-benefit assessments.

The potential costs associated with less extensive soundproofing include lower crew morale and losses in cognitive efficiency. Noise can produce the perception that a situation is more stressful than otherwise would be the case (Driskell et al., 1991) and that noise adversely affects some aspects of cognitive performance (Hockey, 1986). Noise effects may be exacerbated when exposure cannot be controlled by the individual (Glass & Singer, 1972) as would be the case on board a ship exposed to active sonar. It is important, therefore, to understand the effects of sonar exposure on psychological states which may have secondary effects on performance of tasks.

Objectives

The primary objective of this element of the research program on shipboard habitability during low frequency active sonar (LFAS) exposure was to evaluate the effects of exposure on mood states. Mood states are psychological reactions which may be produced by situational factors. Over time, factors which induce negative mood can be expected to cumulate to produce enduring negative morale.

The chosen approach to evaluating mood relied on broad coverage of this general domain based on two different theoretical views of mood. In some theoretical models, the influence of the situation on mood depends on how the person interprets the situation. In other theoretical models, situational factors affect mood states by influencing physiological states that are one component of emotional experience. Other models combine these two approaches, so that the situation can affect mood by producing physiological changes, providing cues for the

interpretation of such changes, or both. Different theoretical models of mood vary with regard to the importance assigned to the interpretive significance and physiological arousal effects of the situation as determinants of mood states with the result that there is no current consensus regarding the best model to account for the influence of situational factors on moods.

The lack of theoretical consensus about how a situation affects mood does not mean that the effects of LFAS on mood cannot be investigated efficiently. Useful evaluations can be obtained by including mood measures which would be sensitive to noise no matter which mechanism is operating. Previous psychometric work has developed measures of states such as anger, anxiety, depression, and happiness which depend on cognitive mechanisms (e.g., McNair, Lorr, & Droppleman, 1971; Ryman, Biersner, & LaRocco, 1974) and measures of activation level which assess the subjective awareness of arousal (e.g., Thayer, 1989). The approach in this study was to include representative measures derived from both approaches to ensure that the assessments would be sensitive to effects of LFAS on mood no matter which theoretical model was more appropriate for the specific situation being investigated. The first objective of this project, therefore, was to provide a comprehensive representation of the mood and activation effects of LFAS exposure.

Mood responses to LFAS exposure may be limited primarily to individuals whose personalities predispose them toward strong emotional reactions to moderate stimuli. If so, it may be more appropriate to set LFAS exposure standards with susceptible individuals as the reference group than to use the average effects of LFAS exposure across all types of people for this purpose. Focusing on susceptible individuals would ensure that even high-risk individuals in the general Navy population are protected adequately. The second objective of this project element was to characterize the personality of the average study participant and determine whether personality affected the reaction to the sonar exposure.

Research Hypotheses

Based on prior research findings regarding noise, mood states, and personality, the following hypotheses were tested.

> Hypothesis 1 -- Noise Effects: Relative to 83 dB LFAS, 89 dB LFAS will produce more negative moods and lower activation.

Hypothesis 2 -- Personality and Noise Effects: The effect of more intense sonar will be greater among individuals whose personality traits predispose them to respond emotionally to environmental stimuli.

If the first hypothesis were supported, mood effects would be one useful criterion for choosing one intensity over another. If the second hypothesis were supported, it would be reasonable to give susceptible individuals special scrutiny when setting exposure standards.

Method

Sample

Study participants were male (n=45) servicemen in the Marine Corps with an average age of 22.46 years (SD = 2.93) and a range of 19 years to 34 years who volunteered to participate after the study was described to them. The majority were Caucasian (55.6%) with fewer participants who described themselves as Hispanic (24.4%), Black (15.6%), or Other (4.4%).

Personality Assessment

The NEO Personality Inventory (Costa & McCrae, 1985) provided measures of five major dimensions of personality which have been proposed as a comprehensive general description of the personality domain. The five dimensions measured were neuroticism, extraversion, openness to experience, conscientiousness and agreeableness.

Neuroticism assesses adjustment versus emotional instability. This dimension identifies individuals prone to psychological distress, unrealistic ideas, excessive cravings or urges, and maladaptive coping responses.

Extraversion assesses quantity and intensity of interpersonal interaction, activity level, need for stimulation, and capacity for joy.

Openness to experience assesses proactive seeking and appreciation of experience for its own sake. This dimension looks at the toleration for and exploration of the unfamiliar.

Conscientiousness assesses the individual's degree of organization, persistence, and motivation in goal-directed behavior. Extreme scores contrast dependable, fastidious people with those who are lackadaisical and sloppy.

Agreeableness assesses the quality of one's interpersonal orientation along a continuum from compassion to antagonism in thoughts, feelings and actions.

Prior research with U.S. Navy recruits has shown that neuroticism, extraversion, and conscientiousness predict emotional reactions to basic training (Vickers, Kusulas, & Hervig, 1991). In addition, agreeableness has been associated with the tendency to respond to challenges with hostility and anger (Dembroski & Costa, 1987). These four dimensions of personality, therefore, were regarded as the most likely indicators of sensitivity to environmental stimuli. More adverse effects of noise were expected for those individuals who were high on neuroticism and low on extraversion, conscientiousness, and agreeableness.

The representativeness of the research sample with respect to critical psychological attributes was a concern because the results were to be generalized to an overall population. Sample representativeness for the present study was assessed by comparing the obtained personality score distributions to personality score distributions for recruits who graduated from U.S. Navy recruit training (Table 1). This comparison was made because graduating recruits form the pool from which the shipboard personnel who would be exposed to LFAS during operational deployments are drawn.

Table 1

Personality Profile of Study Participants

Scale	Mean	S.D.	t-test	Sig.	Variance Ratio
Neuroticism	1.72	.35	-4.24	.001	.68
Extraversion	2.33	.36	-1.68	.051	.98
Openness to Experience	2.23	.36	-1.34	.094	1.13
Conscientiousness	2.68	.38	2.54	.008	.54
Agreeableness	2.32	.31	-1.15	.129	.81

NOTE: t-test and variance ratio results based on comparison of present means and variances, respectively, to the corresponding statistics for recruits who graduated from basic training (n = 2240 - 2248).

The sample produced a relatively low average score for neuroticism and a high average score for conscientiousness with weaker trends toward lower scores for extraversion, openness, and agreeableness. The difference for neuroticism represented an effect size of 0.52 relative to recruits, while that for conscientiousness amounted to an effect size of 0.28. These effect sizes would be medium and small, respectively, by Cohen's (1969) criteria. Study participants also tended to be less variable than the graduating recruits, especially on Conscientiousness (variance ratio = .54) and Neuroticism (variance ratio = .68).

Preliminary analyses compared the personality profiles for the groups exposed to different LFAS intensity levels. If the groups differed significantly on mood-relevant personality attributes, these differences could bias estimates of the LFAS exposure effects. A multivariate analysis of variance indicated that the groups were comparable in terms of overall personality profiles (multivariate $F < 1.00$) and on each personality dimension separately (absolute $t < 1.00$ for each scale).

Mood Assessment

Mood was measured by a 51-item questionnaire. Forty items were drawn from the Mood Questionnaire (MQ; Ryman, et al., 1974). The additional items were chosen to ensure adequate measurement of activation constructs defined by Thayer (1989) and the warmth construct defined by McNair, et al. (1971). These additions to the standard measures provided better coverage of the concepts of activation effects and positive emotions. Broad coverage was a prerequisite for sensitive evaluation of mood effects given the lack of theoretical consensus regarding the key constructs to measure in this domain (cf., pp. 3-4). Scale item content was:

Anger: irritated, mean, burned-up, grouchy, annoyed, angry

Happiness: contented, steady, happy, pleased, satisfied, good

Anxiety: afraid, alarmed, uneasy, hopeless, insecure

Depression: low, blue, miserable, downcast, depressed, sad

Warmth: friendly, accepting, good-natured, kindly, warm-hearted, forgiving

Energy: lively, active, energetic, vigor, full-of-pep

Fatigue: sleepy, tired, drowsy, wakeful, wide-awake

Tension: jittery, clutched-up, intense, fearful, tense

Calm: calm, placid, at rest, still, quiet

The mood questionnaire was administered three times a day throughout the study. The first administration was between 1000 and 1200 hours, the second administration was between 1300 and 1500 hours, and the third administration was between 1800 and 2000 hours. The questionnaire was completed on each day of the study, but only the data from the day preceding LFAS exposure, the day of LFAS exposure, and the day after LFAS exposure were used in the analyses reported here. The novelty of the setting and the initial exposure to the research procedures made mood and activation measures from the first day in the laboratory unsuitable as baseline measures.

Analysis Procedures

All analyses were conducted with the SPSS-X statistical package (SPSS, Inc., 1988). Effects of LFAS exposure as a function of time of day were evaluated by multivariate analyses of variance (MANOVAs) for repeated measures. Time of day (Morning versus Afternoon versus Evening) and day of testing (Baseline versus Exposure versus Recovery) defined two completely-crossed within-person factors in these analyses. Sonar intensity (83 dB versus 89 dB) defined a between-person factor. A separate MANOVA was performed for each mood measure.

The hypothesis that personality differences would have a stronger effect on mood and activation when the noise intensity was higher was tested by two-way analyses of variance with personality (Low scorers versus High scorers) and Noise Intensity (83 dB versus 89 dB) as between-persons factors. Separate analyses were conducted for each personality dimension with "low" scorers defined as those individuals with scores below the sample mean on the dimension and "high" scorers as those individuals with scores above the sample mean on the dimension. Each mood and activation measure was considered separately for both exposure effects and recovery rates which were defined as follows:

Exposure effect = Mood during LFAS exposure - Mood the previous day

Recovery rate = Mood the day after LFAS exposure - Mood during LFAS exposure

Exposure effects and recovery rates were computed for entire days because the analysis of exposure effects showed no effects of time of day on mood.

Results

General Effects of LFAS Exposure and Personality

Considering the 83 dB and 89 dB groups combined, LFAS exposure decreased happiness ($p < .008$), warmth ($p < .003$), and energy ($p < .038$) and increased anger ($p < .008$). Significant recovery effects included decreased anger ($p < .017$) and depression ($p < .045$) and increased energy ($p < .015$). With regard to personality, 4 of 45 correlations (9 mood measures x 5 personality scales) were statistically significant ($p < .05$) for exposure effects and 6 of 45 were significant for recovery effects. Details of the findings pertaining to these general effects of LFAS exposure and personality are given in Appendix A, but are not considered further here because they do not bear on the central issue of determining whether 89 dB LFAS exposure produced different effects than 83 dB LFAS exposure.

Average Effects of LFAS Intensity Differences

The effects of different LFAS intensity levels on mood and activation would have been evident in two interaction effects in the Intensity x Day x Time MANOVAs. If LFAS intensity affected mood over the entire 24-hour exposure period, the effects should be identifiable as an Intensity x Day interaction. If LFAS intensity affected mood only at a particular time of day, there would be an Intensity x Day x Time of Day interaction. Neither interaction even approached statistical significance for any mood measure ($p > .12$) even though a total of 18 significance tests were performed. Thus, these analyses provided no evidence that intensity of sonar noise affected the mood of the average study participant.

Personality-Intensity Interactions

If the hypothesis that the relationships between personality and mood become more pronounced as the intensity of the LFAS increased were correct, correlations between personality measures and mood would be stronger in the 89 dB group than the 83 dB group. This difference would be identified in the ANOVAs by a significant interaction between personality and LFAS intensity.

The results did not support the hypothesized effects of differences in intensity on personality-mood relationships even though some significant personality by intensity interactions were identified. A total of 45 tests for interactions representing different combinations of 5

personality dimensions with 9 mood/activation measures were performed to evaluate the hypothesis for exposure and for recovery. Analysis results were:

(a) Nine of 45 interactions were statistically significant ($\underline{p} < .05$) for exposure effects, but only 1 of 45 was significant for recovery. The former rate was greater than expected by chance ($\underline{p} < .0004$ by the binomial expansion), but the latter was not ($\underline{p} > .900$).

(b) The statistically significant interactions for exposure effects included four effects for neuroticism (happiness, $p < .008$; warmth, $p < .003$; energy, $p < .004$; fatigue, $p < .012$), two for extraversion (anxiety, $p < .028$; warmth, $p < .004$), two for agreeableness (anger, $p < .035$; anxiety, $p < .040$), one for Openness (anger, $p < .024$), and none for conscientiousness.

Table 2

Correlation of Personality and Mood/Activation During LFAS Exposure

Personality Scale	Mood/Activation Scale	83 dB LFAS	89 dB LFAS
Neuroticism	Happy	.56	-.36
	Warmth	.56	-.33
	Energy	.68	-.42
	Fatigue	-.62	.30
Extraversion	Anxiety	.47	-.09
	Warmth	.66	-.13
Agreeableness	Anger	.56	-.10
	Anxiety	.51	-.03
Openness to Experience	Anger	.56	-.12

Note: Table entries are point biserial correlations between dichotomized personality measures (cf., p. 10) and the mood/activation measures.

The significant interactions did not conform to the a priori expectation that the differences between the high and low personality groups would be greater at 89 dB than at 83 dB. Table 2 presents these interactions expressed as point biserial correlations between the dichotomized personality measures and the dependent variables. If expectations had been fulfilled, these correlations would have the same sign for 83 dB and for 89 dB, but the absolute

value of the correlations would be greater in the 89 dB group. Instead, the significant interactions all involved correlations with the opposite sign in the two groups with the larger absolute value in the 83 dB group. In addition, it was noteworthy that the correlations in the 83 dB group uniformly were opposite what was predicted on the basis of prior research (cf., p. 6).

Discussion

Although LFAS exposure affected mood, the effects were the same whether the intensity was 83 dB or 89 dB. Individuals with personality traits that predisposed them toward strong emotional reactions to environmental stimuli reacted to the LFAS more than did those lacking these traits. However, there was no evidence that the relationship between emotional reactivity and mood response to LFAS exposure was greater at 89 dB than at 83 dB.

LFAS Intensity Effects

Several possible methodological explanations for the absence of mood differences between the 83 dB and 89 dB LFAS exposure groups can be ruled out on the basis of the present analyses. The possibility that the mood measures were insensitive to LFAS exposure can be ruled out on the basis of the observed general effects of LFAS exposure and the correlations between changes and personality attributes (Appendix A). Differences in the personality composition of the groups which might have offset the effects of differences in LFAS intensity can be ruled out in light of the finding that the groups had closely comparable personality profiles (cf., pp. 6-7). The possibility that the two intensities produced differences in mood and activation large enough to be practically significant which were statistically nonsignificant was considered because statistical significance tests depend on both effect size and sample size (Rosenthal & Rosnow, 1984). Direct examination of the effect sizes applying criteria suggested by Cohen (1969) indicated that the LFAS intensity comparisons generally were in the "no effect" range and that the few that were larger than this were toward the low end of the "small effect" range. On the whole, the distribution of effect sizes was consistent with the assumption that true effects were very small if there were any at all.

Effects of Personality

Susceptible individuals responded more strongly to LFAS exposure than did individuals with more resistant personalities (Appendix A). However, there was limited evidence that the

magnitude of the difference was related to LFAS intensity. Where significant personality-intensity interactions were observed, the general form of the interaction was superficially inconsistent with hypothesized effects. In particular, personality-mood correlations in the 83 dB group were the opposite of what would be expected from prior research. Actually, this apparent deviation may be misleading as the sample size in the 83 dB group was so small that the observed correlations may represent chance deviations from a true correlation of zero. If so, the results could be interpreted as indicating that susceptible individuals begin to experience more negative affect and lower activation somewhere in the 83 dB to 89 dB range. In this case, investigations focusing on susceptible individuals might be appropriate for setting exposure limits and making design decisions. It would be premature to adopt this position at this time as the data base for inferences is too limited. The topic will receive more attention in a report of a parallel study comparing 77 dB and 89 dB exposures.

Issues for Future Consideration

The conclusions from any study necessarily are limited by the study methodology. Although some potential methodological biases for the present findings could be ruled out for the reasons given above, other possibilities remain as issues for future consideration.

Sampling bias was one methodological factor which could affect the accuracy of the conclusions from the present study. This possibility exists because the distributions of scores for neuroticism, conscientiousness, extraversion, and agreeableness had lower mean values and smaller variances than the corresponding values for a large sample of graduating U.S. Navy recruits (pp. 6-7). This pattern of findings suggests that those individuals who are psychologically susceptible to environmental stimuli may have chosen not to participate in the study. If so, generalizing the findings from the present sample to the entire fleet population is risky. The difference between 83 dB and 89 dB LFAS exposure effects on mood might be substantial in highly susceptible individuals even though this effect was small over the range of individual differences sampled in this study.

The suggestion that sampling bias was present in this study depends on the assumption that graduating Navy recruits are representative of the personnel manning ships in the fleet. This assumption is questionable because low conscientiousness, high neuroticism, and low extraversion are established correlates of attrition in military and civilian organizations (Kamp & Hough,

1988). The differences between the sample and the recruit population may reflect no more than the ongoing effects of attrition after basic training in removing certain personality extremes from the Navy population. Other arguments such as changes in personality on the basis of age and experience also could be suggested.

The legitimacy of arguments regarding the possible sample biases would be determined best by surveying fleet personnel to determine the true distribution of personality scores in the population of interest. If it were demonstrated that highly susceptible individuals were present in the sample in smaller numbers than in the fleet, studies to determine the reactions of these individuals to LFAS exposure would be useful. In the absence of data showing that the distributions of personality scores for the sample actually were representative of fleet personnel, caution is appropriate when generalizing from the study sample to the general Navy population.

Another methodological qualification that applies to the present findings is that the conclusions apply only to LFAS exposure intensities between 83 dB and 89 dB. Lower intensities might eliminate mood effects of LFAS exposure, a possibility which is being tested in ongoing evaluations of 77 dB LFAS. Also, increasing noise intensity beyond 89 dB could produce more substantial mood and activation effects than were observed here, but possible adverse effects on hearing have been observed with even 24-hour exposure to 89 dB sonar as described in other reports from this project. Given a high risk of hearing impairment at these levels in excess of 89 dB, intensities in this range are not reasonable design alternatives.

The brevity of exposure to LFAS is the last important methodological qualification for the study conclusions. A single 24-hour exposure probably is not representative of what can be expected under operational conditions. Operational conditions might include longer periods of continuous exposure or unpredictable shorter periods of exposure. Under these conditions, the differences between 83 dB and 89 dB might become evident.

Conclusions

Acute exposure to LFAS tends to cause moods to be more negative and activation to be lower. The average effect of LFAS exposure on mood is modest although it does tend to be greater in sensitive individuals. However, neither the average effect nor the effect in susceptible individuals changes when intensity is increased from 83 dB to 89 dB. Therefore, **mood effects do not give any basis for choosing between 83 dB and 89 dB sonar intensities**. These

conclusions regarding the effects of LFAS are limited to the range of sonar intensities studied and might be modified by further examination of the other methodological issues discussed above.

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Appendix A

Simple LFAS Exposure Effects on Mood and Personality Correlates of Those Effects

This appendix describes the simple exposure effects of LFAS and the relationship between personality and the magnitude of responses to that exposure. The term "simple exposure effects" refers to the effect of exposure to LFAS without distinguishing between the 83 dB and 89 dB groups.

Effects of LFAS Exposure

The reasonable expectation that exposure to sonar noise would adversely affect mood and activation was supported. Exposure to noise was associated with decreased happiness and warmth and increased anger (Table A-1). Depression tended to increase, but this trend was only marginally significant statistically. The statistically significant effects of noise exposure on activation were limited to a drop in energy levels. Mood measures the day after exposure indicated a general tendency toward improved mood and increased activation. However, only the changes for anger, depression, and energy met standard statistical significance criteria.

The exposure and recovery effects were modest in absolute size. As indicated in Table A-1, mean changes were less than .27 (absolute) for every scale considered. The median changes were less than .10 (absolute) for both exposure effects and recovery effects. Another indication of the modest effect size is provided by the confidence intervals for the statistically significant effects. The boundaries of these intervals indicate the range of possible values which have a 95% probability of including the true population effect size. If attention is directed to the confidence limit with the smaller absolute value for each mood or activation measure, it will be seen that the data do not rule out the possibility that all of the true effect sizes were .08 or less (absolute value). This effect size is considered small to nonexistent by Cohen's (1969) standards.

Personality-Mood Relationships

Bivariate correlations between personality and mood measures were examined to test the hypothesis that personality predispositions would predict the size of mood and activation effects of exposure to sonar noise. Exposure effects and recovery rates were defined as in the preceding analyses, and individual correlations were considered significant if $\underline{r} > .20$ (absolute). This criterion is lenient statistically, corresponding to a one-tailed significance level of $p < .106$.

Table A-1
Effects of Noise Exposure on Mood:
Exposure Effects (E) and Recovery Rates (R)

		Average	95% Confidence Limits Lower	Upper	Statistical Significance
Mood States					
Happy	E	-.168	-.289	-.046	.008
	R	.024	-.071	.120	.611
Warmth	E	-.214	-.350	-.079	.003
	R	.064	-.039	.167	.218
Anger	E	.270	.073	.467	.008
	R	-.216	-.390	-.042	.017
Fear	E	.045	-.031	.121	.239
	R	-.015	-.112	.0872	.756
Depression	E	.120	-.012	.252	.074
	R	-.125	-.248	-.003	.045
Activation States					
Calm	E	-.075	-.168	.018	.111
	R	-.018	-.090	.054	.618
Energy	E	-.126	-.245	-.007	.038
	R	.124	.025	.222	.015
Tired	E	-.089	-.206	.028	.131
	R	-.035	-.168	.098	.598
Tension	E	.053	-.061	.168	.351
	R	-.050	-.157	.057	.352

A lenient significance criterion was adopted to allow for the low statistical power of significance tests with the present sample size, the expected effects of restriction of range (cf., pp. 6-7), and the low reliability of difference measures. As indicated in Table A-2, The major findings were:

(a) The frequency of correlations which met the significance criterion was greater than chance for exposure effects (10 of 45, $p < .018$) and recovery rate (13 of 45, $p < .0006$).

(b) Neuroticism, conscientiousness, and agreeableness were the primary correlates of exposure effects. High scorers on neuroticism tended to show larger than average decrements in calmness and interpersonal warmth and greater than average increases in depression (Table A-2). High scorers on conscientiousness showed greater than average increases in happiness, energy, and anxiety. High scorers on agreeableness showed greater than average increments in energy and calmness and lower than average increments in tension.

(c) Neuroticism and openness to experience were the primary correlates of recovery rate. Higher than average neuroticism scores were associated with greater recovery for anxiety, depression, fatigue, and calmness. Openness to experience was associated with greater recovery for happiness and energy and greater than average decrements in anxiety and tension.

Table A-2

Correlations between Personality and Mood Effects of Sonar Noise

Personality Dimension	Mood Scale	r	Significance Level
Exposure Effects			
Neuroticism	Depression	.254	.052
	Warmth	-.202	.100
	Calm	-.330	.016
Extraversion	Happy	.253	.056
Openness	None		
Conscientiousness	Happy	.248	.059
	Anxiety	.247	.057
	Energy	.265	.045
Agreeableness	Energy	.300	.027
	Tension	-.321	.019
	Calm	.246	.058
Recovery Rate			
Neuroticism	Anxiety	-.249	.061
	Depression	-.322	.021
	Warmth	.250	.060
	Tired	-.264	.050
	Calm	.263	.050
Extraversion	Tired	-.285	.038
Openness	Happy	.294	.033
	Anxiety	-.263	.051
	Energy	.469	.001
	Tension	-.256	.055
Conscientiousness	Tired	-.204	.104
	Tension	-.206	.101
Agreeableness	Calm	-.222	.084

Note: All correlations $\geq$ 0.20 (absolute) are reported, and significance levels are one-tailed.

Table A-3

Summary of Significant (p < .01) Personality by Noise Intensity Interaction Effects

Noise Intensity: Personality Variable:	83 dB Low	83 dB High	89 dB Low	89 dB High
Neuroticism				
Happiness	-.46	.07	.06	-.23
Warmth	-.45	.24	-.06	-.24
Energy	-.47	.02	.13	-.20
Extraversion				
Warmth	-.67	.15	-.15	-.15

Note: The table entries are the mean exposure effects for the different intensity and neuroticism groups. For example, in the low neuroticism group, LFAS exposure at 83 dB produced a decrease in happiness of -.46 points relative to the baseline day when mood was averaged over the three measurements taken each day.

As a concrete example of the difference between the interactions expected at the outset of the study and the form of the observed interactions, consider happiness and neuroticism. For this combination of variables, the hypothesis makes a two-part prediction. First, high scores on neuroticism would be associated with a larger drop in happiness when exposed to LFAS. Second, the difference between high and low neuroticism scorers with respect to this change in happiness from baseline to LFAS exposure would be greater at 89 dB than at 83 dB.

The observed effects of 83 dB noise on happiness shown in Table A-3 did not conform to either of these predictions. High neuroticism was associated with a larger drop in happiness in the 89 dB group, but the largest average drop in happiness was observed for participants with low neuroticism scores who were exposed to 83 dB LFAS. The difference between the high and low scorers on neuroticism was less at 89 dB (.29 absolute difference) than at 83 dB (.53 absolute). The significant interactions not shown in Table A-3 generally produced larger differences at 89 dB than at 83 dB, but all showed the reversal in the sign of group differences between 83 dB and 89 dB. Thus, none of the interactions which were statistically significant in this study produced the predicted pattern of results.

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This component of the low frequency active sonar noise (LFAS) exposure research project evaluated the effects of sonar exposure on mood and subjective activation. Volunteer participants (n=45) exposed to sonar at 83 dB (n = 11) or 89 dB (n = 34) were studied. Mood and activation were adversely affected by LFAS onset, but the effects of exposure to 89 dB were the same as those for exposure to 83 dB even in subjects whose personality traits should make them exceptionally sensitive to the exposure. Mood and activation effects of LFAS exposure do not provide a basis for choosing between the exposure intensities considered here because these effects were the same for 83 dB and 89 dB.

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